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Polar climate predictability seasonal to multi-decadal: Initializing and predicting anomalies of Arctic sea ice

Steffen Tietsche[†]; Dirk Notz; Johann Jungclaus; Jochem Marotzke
[†] Max Planck Institute for Meteorology, Germany
Leading author: steffen.tietsche@zmaw.de

Sea-ice initial conditions contribute to seasonal to decadal predictability of polar climate. For skillful predictions, coupled climate models hence need to be initialized with sea-ice conditions that are both close to observations, and compatible with model dynamics. Here, we investigate the feasibility of sea-ice data assimilation in the coupled climate model ECHAM/MPI-OM, and present first results on how the sea-ice data assimilation improves predictive skill for sea ice. For the sea-ice data assimilation, we examine how observations of Northern Hemisphere sea-ice concentration can be used to improve the simulated ice volume and ocean surface properties. We employ a simple nudging approach for ice concentration, and we prescribe the analysis increments for ice volume, sea surface salinity and temperature as a function of the concentration analysis increments. Although the simulation of ice concentration is almost always improved, the quality of the simulated ice volume critically depends on the choice for the functional dependence between the analysis increments of concentration and volume. We find indications that problems in the sea-ice data assimilation arise because the coupled model provides strong feedbacks on the analysis increments. Schemes that conserve ice volume or ice thickness in the assimilation step, as they have been suggested in other studies, do not give satisfying results in our data assimilation framework. Instead, we suggest a new scheme for sea-ice data assimilation with volume analysis increments that are proportional to concentration analysis increments. This scheme is able to significantly improve the analyzed sea-ice state using only observations of ice concentration. To quantify the benefit of sea-ice initialization for seasonal to decadal predictions, we perform perfect-model experiments, where the sea-ice state of one model run is assimilated into another run with the very same parameters, but with a different realization of natural variability. Predictions then start from the assimilation run, and we can quantify prognostic potential predictability. Based on previous findings, we expect that there is direct predictability of sea-ice anomalies for at least a few months ahead. With the perfect-model predictability approach, we will also be able to assess if the sea-ice assimilation has an impact on processes that act both on slower time scales and beyond the Arctic.